



# Exploration EVA Concept of Operations

EVA Exploration Workshop  
July 25, 2019

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# Agenda



- **EVA-EXP-0042, The Exploration EVA Concept of Operations**
- **Document Tree and Information Flow**
- **Destination Classes for EVA**
- **Scope of 03 July 2019 Updates to EVA-EXP-0042 Baseline**
- **Lunar Science Updates for Revision A (03 July 2019)**
- **Architectural Mission Scenarios for EVA on Lunar Surface**
- **Content in Exploration EVA Con Ops**

*"We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too."*

– John F. Kennedy







# EVA-EXP-0042, The Exploration EVA Concept of Operations



The ***Exploration EVA Concept of Operations*** captures NASA's current Exploration mission architecture options, concepts of operations, stakeholder expectations, and high level definition of the prospective capabilities and interfaces associated with performing an Extravehicular Activity (EVA) using the Exploration EVA System – including an Exploration EVA Suit – during future missions to cislunar space, a redirected asteroid, a Near Earth Asteroid (NEA), Mars' orbit, the moons of Mars (Phobos and Deimos), the Lunar surface, and the surface of Mars.

This document is a complete set of concepts of operations for all possible mission types, agnostic to any specific 'program'.

Primary focus for the 03 July 2019 revision (A) was an update to the lunar surface con ops, including the science objectives driving the mission and EVA operations, a breakdown of the architectural mission scenarios, and xEVA System capabilities needed to successfully complete the missions.



EVA-EXP-0042  
REVISION A

EFFECTIVE DATE: JULY 03, 2019

EXTRAVEHICULAR ACTIVITY (EVA) OFFICE  
EXPLORATION EVA SYSTEM  
CONCEPT OF OPERATIONS

EAR ECCN: EAR99

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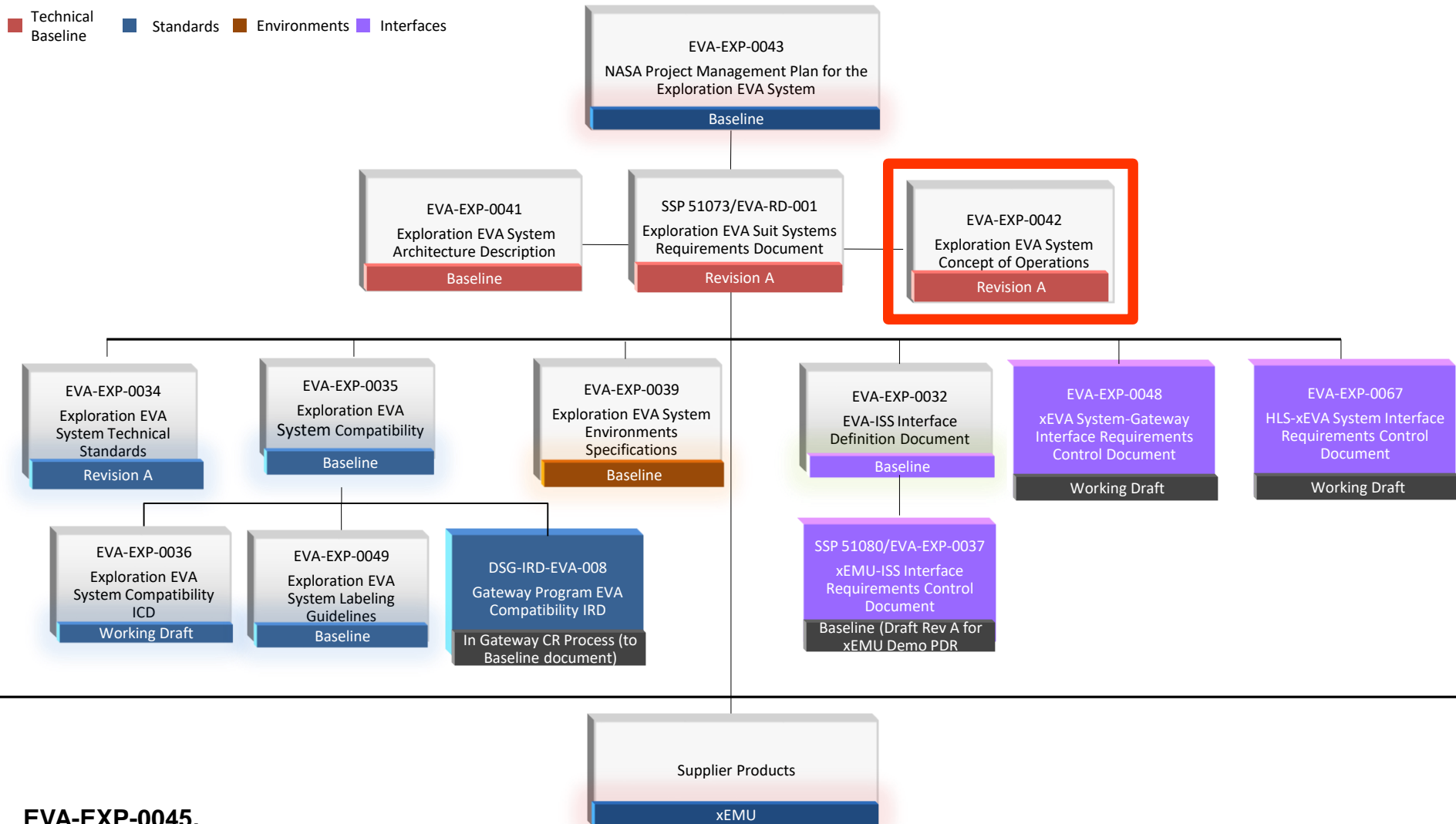
EVA-CM-001

08/07/2018





# Exploration EVA System Document Tree

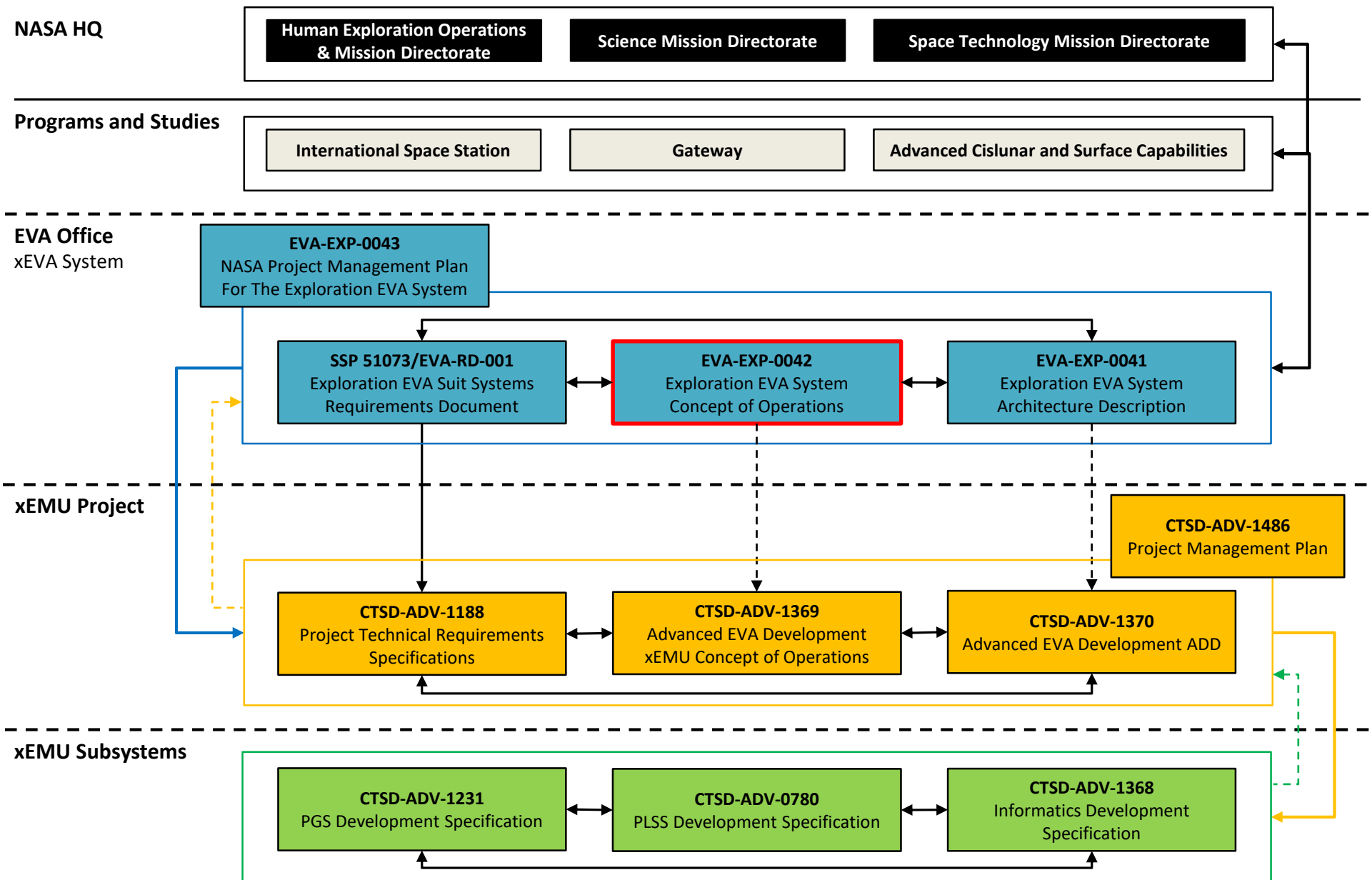


**EVA-EXP-0045,  
Exploration EVA System  
Document Tree**

07-10-2019 Rev



# Exploration EVA System Information Flow for Con Ops







# Destination Classes for EVA



## MICRO-GRAVITY EVA ON A SPACECRAFT (ENGINEERED SURFACE)



## MICRO-GRAVITY EVA ON A SMALL NATURAL BODY (ASTEROID OR MOONS OF MARS)



## PARTIAL-GRAVITY EVA ON LUNAR SURFACE (IN A VACUUM)



## PARTIAL-GRAVITY EVA ON MARS SURFACE (IN PARTIAL-ATMOSPHERE)

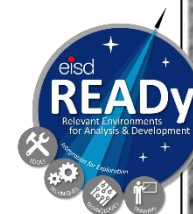
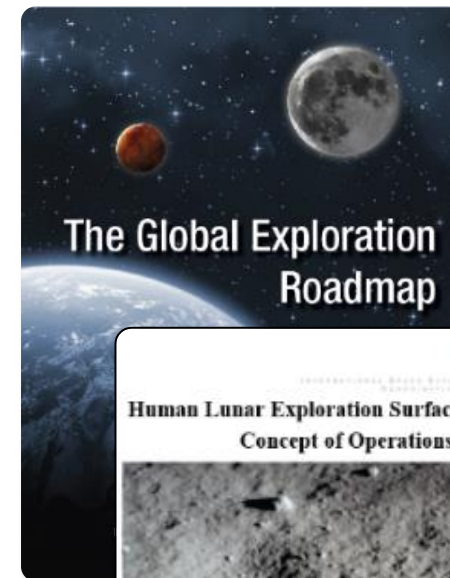




# Scope of 03 July 2019 Updates to EVA-EXP-0042 Baseline



- Updates made throughout document, with significant additions to:
  - Exploration EVA System & Capabilities Overview
  - Partial-Gravity EVA on Lunar Surface (in a Vacuum)
    - Added **Design Reference EVA**  
(Initial Short Stay, Two Crew, Unpressurized Rover)
  - EVA Contingencies and Rescue
- Lunar surface mission updates based partially on:
  - 2018 and 2019 Advanced Cislunar and Surface Capabilities (ACSC) studies
  - Exploration EVA Concept of Operations Analysis for ACSC and Human Landing System (HLS)
  - January 2018 *Global Exploration Roadmap* (GER)
  - May 2017 draft of the International Space Exploration Coordination Group (ISECG) *Human Lunar Exploration Surface Campaign Concept of Operations*
  - Integrated operational tests (analog missions) integrated and executed by the READy team
- Utilized the xEVA Con Ops Working Group as a mechanism to provide focused cross-integration and stakeholder input to the high level definition of the mission architecture, capabilities needs, and concepts of operations
  - Team included representatives from Exploration EVA (XX), Science (ARES/XI), H3PO (SK), EVA Tools (EC7), and xEMU Project (EC5/CX3)





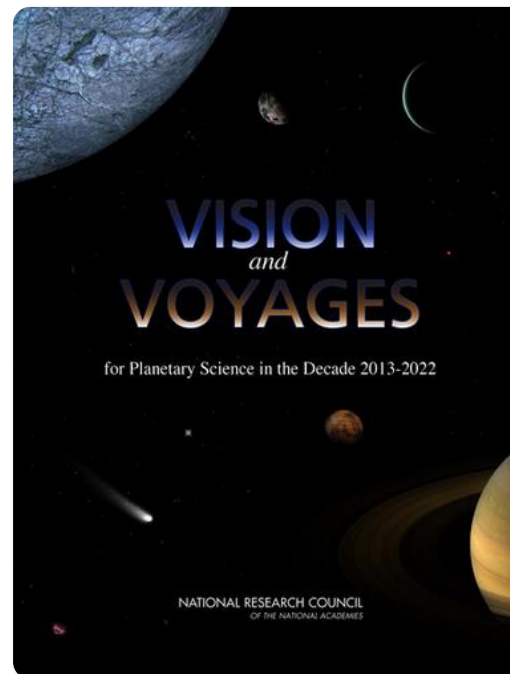
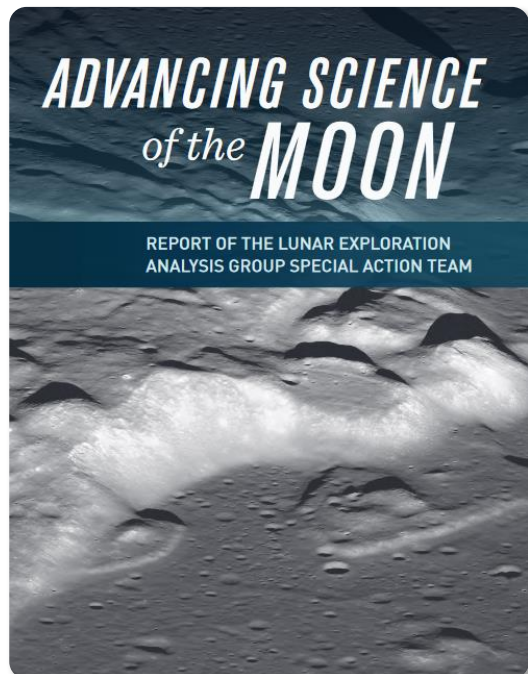
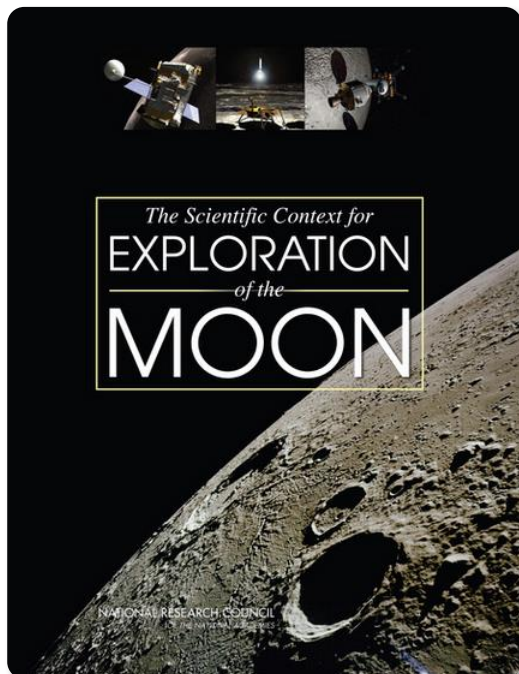


# Lunar Science Updates for Revision A (03 July 2019)



Addition of Science Objectives for the Lunar Surface and the Exploration Regions on the Lunar Surface were based on the following:

- Extensive technical meetings with JSC's Astromaterials Research and Exploration Science Division
- January 2018 *Global Exploration Roadmap* (GER)
- 2007 National Research Council's (NRC) *Scientific Context for the Exploration of the Moon* (SCEM)
- 2017 Lunar Exploration Analysis Group (LEAG) *Advancing Science of the Moon* (ASM) Specific Action Team (SAT) Report
- NRC *Vision and Voyages for Planetary Science*
- *A Global Lunar Landing Site Study to Provide the Scientific Context for Exploration of the Moon*
- January 2018 The Lunar Science for Landed Missions Workshop







# Architectural Mission Scenarios for EVA on Lunar Surface



- **Minimal Stay Mission** (“Flags & Footprints”, Two Crew)
  - Surface stay duration: ~12 hours
  - EVA egress: Crew Ascent Module is airlock
  - Traverse distance from lander: ~1.5 – 2 km walking
- **Initial Short Stay Mission** (Lunar Daylight Sortie, Two Crew)
  - Surface stay duration: 6.5 days (156 hr)
  - EVA egress: Airlock/suitlock on lander (trade still in work)
  - Traverse distance from lander:
    - ~1.5 – 2 km walking
    - ~7.5-10 km with unpressurized rover
- **Short Stay Missions** (Lunar Daylight Sortie, Four Crew)
  - Surface stay duration: 14 days (336 hours)
  - EVA egress: Suitlock/airlock on lander, suitlock/airlock on pressurized rover
  - Traverse distance from lander:
    - ~7.5-10 km with unpressurized rover
    - ~12 km with a single pressurized rover (multi-day)
- **Extended Stay Missions** (Lunar Day & Night, Four Crew)
  - Surface stay duration: 42 days
  - EVA egress: Suitlock/airlock on pressurized rover
  - Traverse distance from lander:
    - ~7.5-10 km with unpressurized rover
    - ~12 km with a single pressurized rover (multi-day)
    - >100 km with dual pressurized rovers (multi-day)
- **Long Duration Missions** (Four+ Crew)
  - Surface stay duration: 6+ months





# General Content in Exploration EVA Con Ops



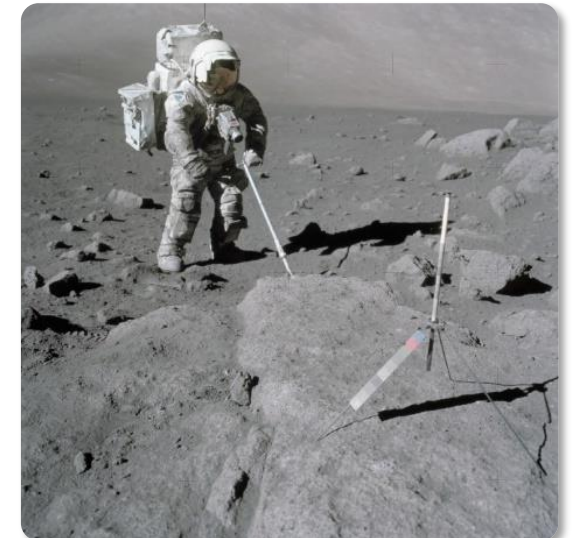
## EXPLORATION EVA SYSTEM STRATEGY

## EXPLORATION OVERVIEW & GOALS

## EXPLORATION EVA SYSTEM & CAPABILITIES OVERVIEW

- Types of EVAs Done During Exploration Missions
- EVA Tasks for Exploration Missions
- Exploration EVA Suit
- EVA Informatics & Support Systems
- EVA Tools and Equipment
- Vehicle Interfaces
- EVA Egress & Ingress (Airlock) Overview
- EVA Phases

## EVA CONTINGENCIES & RESCUE







- MICRO-GRAVITY EVA ON A SPACECRAFT  
(ENGINEERED SURFACE)
  - Concepts of Operations for Microgravity EVA in Low Earth Orbit (LEO) on the International Space Station (ISS)
  - Concepts of Operations for Microgravity EVA in Cislunar Space (Gateway-focused)
- MICRO-GRAVITY EVA ON A SMALL NATURAL BODY  
(ASTEROID OR MOONS OF MARS)
  - Concepts of Operations for EVA on a Captured Asteroid
  - Concepts of Operations for EVA on a Near Earth Asteroid (NEA)
  - Concepts of Operations for EVA on the Moons of Mars







# Partial-Gravity Content in Exploration EVA Con Ops



- PARTIAL-GRAVITY EVA ON LUNAR SURFACE  
(IN A VACUUM)
  - Science Objectives for the Lunar Surface
  - Exploration Regions on the Lunar Surface
  - Architectural Assets for the Lunar Surface
  - Architectural Mission Scenarios for EVA on the Lunar Surface
  - General EVA Ops & Capabilities Common across Lunar Surface Mission Scenarios
    - EVA Frequency and Duration Summaries
    - EVA and Rover Ranges
  - EVA Con Ops for Lunar Surface Missions
    - General EVA Con Ops for Initial Short Stay Mission (Lunar Daylight, Two Crew)
    - General EVA Con Ops for Short Stay Mission (Lunar Daylight, Four Crew)
    - General EVA Con Ops for Extended Stay Mission (Lunar Day & Night, Four Crew)
    - General EVA Con Ops for Long Duration Mission
  - Design Reference EVA
- PARTIAL-GRAVITY EVA ON MARS SURFACE  
(IN PARTIAL-ATMOSPHERE)





# Exploration EVA Concept of Operations



## *Extravehicular Activity, from Low Earth Orbit to the Moon to Mars*

The Exploration EVA System Concept of Operations document describes the mission architecture and concepts of operations associated with the Exploration EVA System and Suit for operating in microgravity, milli-gravity, and on partial-gravity surfaces, within environments that include hard vacuum and partial atmosphere

It provides an understanding of EVA capability needs and concepts of operations for a wide range of Exploration destinations being considered by NASA beyond Low Earth Orbit, from the Moon to Mars

It assesses the system and architectural interactions between Operations, Engineering, and Science

It is utilized to advance the future of the Exploration EVA System and operations, and provides information and rationale for Exploration EVA Suit requirements

It helps realize the needs of EVA equipment and enables the development of concepts for design maturation on the road-to-flight



**Thank you!**

**Questions?**

